ESA 135-2_Flambeau Papers, Park Falls, WI
Steam ESA – Public Report - Final

Company	Flambeau River Papers	**ESA Dates**	August 8th to 10th
Plant	Park Falls, Wisconsin	**ESA Type**	Steam
Product	Paper Products	**ESA Specialist**	Tom Tucker, P.E.

Brief Narrative Summary Report for the Energy Savings Assessment:

Introduction:
On behalf of the Department of Energy, Tom Tucker of Kinergetics LLC conducted a steam system ESA at Flambeau River Papers in Park Falls, Wisconsin from August 8th to August 10th, 2007. The ESA and training activities were provided through the United States Department of Energy-Save Energy Now initiative, which was begun to help the largest natural gas users in the United States identify ways to reduce energy use.

The estimated annual energy cost savings for the projects evaluated is provided in **Table 1** above. If all projects listed are implemented the annual cost savings is estimated at approximately $2,001,000. The average 2006 energy costs were $8.00/MMBtu gas and approximately $0.052/kWh for electricity.

Steam System
There are two boilers on site, one fired on natural gas and one fired on wood. Since the facility is primarily interested in reducing gas use, the gas boiler was the focus of the assessment. The gas boiler efficiency was checked using information available in the control room. Including the feed water economizer the boiler efficiency was estimated at 81-percent. The economizer is contributing approximately 6-percent to the boiler efficiency.

The gas boiler produces an average of 70,000-pph of 320-psig superheated (550°F) steam and the wood boiler produces an average of 150,000-pph of 900-psig superheated (~850°F) steam that is used in a backpressure/extraction generation turbine. Extraction steam at 320-psig is used along with output from the gas boiler to drive two line shaft turbines and backpressure steam at 150-psig is used in the process. The line shaft turbines appear to be contributing to steam imbalance at times that results in expensive steam venting.

Objective of ESA:
The primary objective of the ESA was to identify steam cost reduction opportunities and to have the primary ESA lead become comfortable with the concepts behind use of the DOE steam tools. Particular attention was given to the Steam System Assessment Tool (SSAT), although the use of 3E Plus (v3.2) was also demonstrated used to address insulation related projects.

Focus of Assessment:
SSAT was applied to model cost reduction opportunities identified during walk-throughs and group discussions. The projects of primary interest were use of a condensing economizer on the gas boiler, use of liquid ring pumps instead of steam jet ejectors on the multi-effect evaporator and minimization of vent steam. Other potentially significant projects were reviewed and are discussed below.

Approach for ESA:
The ESA started with an introduction and a brief Power Point presentation introducing the different steam tools. The Steam System Scoping Tool (SSST) was completed during the assessment. The mill scored approximately 65.3-percent. Scores above 75-percent are considered very good and scores below 50-percent are considered poor.

General Observations of Potential Opportunities:
Below are brief descriptions of each opportunity evaluated. Each opportunity has been rated based on the following definitions:

1. Near term opportunities: Include actions that could be taken as improvements in operating practices, maintenance of equipment or relatively low cost actions or equipment purchases.
2. Medium term opportunities: Require purchase of additional equipment and/or changes in the system such as addition of recuperative air pre-heaters and use of energy to substitute current practices of steam use etc. It would be necessary to carryout further engineering and return on investment analysis.
3. Long term opportunities: Require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.

Note: All assumptions should be checked before implementing a project, particularly if significant investment is required. This includes operating hours, which were estimated at 8,760 per year for simplicity.

1. Reduce Steam Demand – Recover Remaining Boiler Exhaust Heat Using Condensing Heat Recovery

Condensing heat recovery (CHR) systems are designed to allow boiler exhaust to be cooled to a much lower temperature (90°F to 130°F) than is possible with a “standard” economizer such as the one on the gas boiler. The benefit is that the water vapor present in the exhaust from fuel combustion contains 8 to 10-percent of the fuel energy input to the boiler. This “latent” heat is not available until the vapor begins to condense at an exhaust temperature of approximately 135°F. Standard economizers are not designed to handle corrosive condensate and are limited to lower exhaust temperatures of 250°F to 325°F depending on the fuel.

During the assessment water flow rate available for the condensing economizer was estimated at 300-gpm. At a stack temperature of 400°F the annual cost savings potential was estimated at approximately $600,000. However, subsequent discussions with mill staff revealed that the available water 1,000-gpm, more than enough for a condensing system to be viable even at higher temperature of 80°F.

Based on the available data, the estimated annual energy cost savings is $930,000. To obtain this savings the average flow requirement is approximately 457-gpm, less than half of what is available.

It appears that the cost for this system will be on the order of $1-million to 1.2-million placing the simple return at approximately one year. This project is recommended for further consideration.

2. Change Boiler Efficiency - Wood Boiler Grate improvement (medium term)

The wood boiler is being considered for a grate upgrade to provide better dispersion of the wood fuel for improved combustion. The new grate is reported to provide a boiler efficiency increase of approximately 2-percent. Details on this particular opportunity were not available, but based on the vendor that was available the projected efficiency gain is worth approximately $425,000 per year with a simple return of less than one year.

This project is recommended for further consideration as appropriate, although it is suggested that the basis for the efficiency gain be understood before proceeding.

3. Consider Replacing Line Shaft Turbines with Electric Drives

Two of the three steam turbines are older 700-hp line shaft drives, which should be efficient to operate as long as the back pressure steam is not wasted. However, due to steam imbalance issues that occur at times, some of the back pressure steam must be vented to the atmosphere. Plant personnel estimated to back pressure steam loss at approximately 4-percent.

Assuming an average load of 70-percent, and an average isentropic efficiency of 52-percent, replacing the steam turbines with electric drives will eliminate venting and provide an annual cost savings of approximately $216,000.

Variable frequency drives and motors to replace the line shaft turbines will likely cost between $300,000 and $350,000. Assuming an installation factor of 1.5, the total installed cost will range from $450,000 to $525,000 and the simple return will range from 2.1 to 2.4 years.

Due to the economic potential and the potential for prevention of further venting as other steam reduction projects are installed, this project is recommended for further consideration and implementation as appropriate.

Notes:

1. Careful consideration should be given to implementation of this project if other large steam demand reduction projects are to be installed. This will help eliminate the possibility of venting due to steam imbalance and maximize overall cost savings potential.
2. Assumptions should be evaluated.

<u>4. Steam Demand Reduction – Use Existing Liquid Ring Pump Instead of Steam Ejectors for Vacuum (medium term)</u>
The multi-effect liquor evaporator presently uses a main condenser (pre-condenser), an inter-condenser and an after condenser with two steam jet ejectors to provide vacuum for the evaporator to operate under vacuum conditions. There is also a liquid ring pump (LRP) installed that was intended to provide vacuum to the evaporator in lieu of the steam ejectors, but that has not been used for about three-years apparently due to performance related issues. A properly applied liquid ring pump should provide adequate vacuum at a lower cost than is possible with the steam jet system. However, the liquid ring pump is only one part of the vacuum system. All components, including condensers and piping must be considered as a unit to ensure proper operation. Assuming that the LRVP can be brought back on-line and will function properly, it should offer a substantial cost savings over the steam jet ejectors.

Based on review of design data and P&ID drawings, the steam ejectors require approximately 2,500-pph of 150-psig motive steam. The annual cost of the motive steam is:
2,500-pph x $11.30/1,000-lb x 8,760-hr/yr = $247,470/yr

The design operating conditions for the LRVP were not available so the pump was assumed to be under full load based on the nameplate rating of 150-hp and an assumed motor efficiency of 94-percent. The annual operating cost is:
150-hp/LRVP ÷ 95% x 0.746-kW/hp x 8,760-hr/yr x $0.052/kWh = $53,655

The estimated net annual energy cost savings per process line is:
$247,470 - $53,655 = $193,815

The cost of water is also a factor but varies depending on the means of cooling (loop versus single pass) and treatment, and is not included here.

Because the LRVP pump is already installed, the primary cost will be replacing the failed piping (use corrosion resistant materials) and testing to be sure the system will perform to specification, the simple return is expected to be less than one year.

Notes:

1. It is important to consider cooling water supply temperature when selecting vacuum equipment since the vacuum capacity of the pump will be impacted. Piping must also be properly designed to eliminate unnecessary pressure drops that could impair the pumps ability to meet proves vacuum requirements.
2. Thoroughly clean the condensers and place them on regular cleaning schedule. A biannual schedule is often adequate but it depends on the site.
3. Prior to putting the LRVP in service, conduct testing to help ensure it still meets design specification and will not require a rebuild.

<u>5. Steam Demand Reduction – Waste Heat Recovery from Sulfur Burner Exhaust (medium term)</u>
The exhaust from the sulfur burner is very hot (~1,800°F) and from an energy standpoint is suitable for use in a waste heat recovery boiler to generate high pressure steam. Analysis indicates that at a sulfur burn rate of 20,000-ppd and 25-percent excess air, a waste heat boiler generating steam at 320-psig (550°F) will provide an annual cost savings of $109,000 per year. Because the steam is being generated at conditions sufficient for the line shaft turbines, there will be no penalty for additional import power.

Based on past experience with similar projects, the simple return will likely be between two and three years.

Note:
While this opportunity does appear to provide a reasonable return, care must be taken since the additional cooling step (steam generation) does not jeopardize the acid making process.

6. Reduce Steam Demand – Minimize DA Venting (near term)
The vent on the gas boiler DA tank allows removal of dissolved oxygen and other gases from feedwater to protect the boiler and other components of the steam system from pitting (corrosion damage). Generally, the venting rate is approximately 1/10 of one percent of the design steam capacity. The total steam system capacity for the gas boiler is approximately 120-kpph so a reasonable vent rate is on the order of 120-pph. Visual observation of the vent plume indicates a vent rate likely in the range of 1,000-pph.

A DA vent rate reduction to approximately 120-pph will provide an annual cost savings of approximately $83,000. The cost to implement this project should be minimal and the return less than three-months to nearly immediate depending on what is required to control venting. This project is recommended for implementation as appropriate.

Notes:
1. As a guide, a 2-inch free space over the vent and a plume approximately 2-feet high are good targets.
2. The chemical use should be monitored for changes that indicate increased oxygen levels. See your chemical service provider for more information.

7. Increase Boiler Efficiency: Improve Blowdown Heat Recovery (medium term)
The mill is already recovering heat from boiler blowdown by using it directly to preheat mill water to 80°F. However, since the mill is interested in improving steam production efficiency to off-set natural gas, the blowdown heat would be better used if first sent to a flash vessel with the remaining heat used for mill water heating. The Btu value of the steam formed by flashing can the made up with other lower quality heat sources that are otherwise unusable. As a result, there will be a net cost savings.

The anticipated annual cost savings for this opportunity is $25,000. Blowdown heat recovery systems of this type generally have a simple return in the range of one year with high natural gas prices. However, given that additional piping will likely be needed, the return is estimated to range from one to three years, although an accurate estimate is not possible without a more detailed understanding of the piping requirements. Nevertheless, this project is recommended for further consideration.

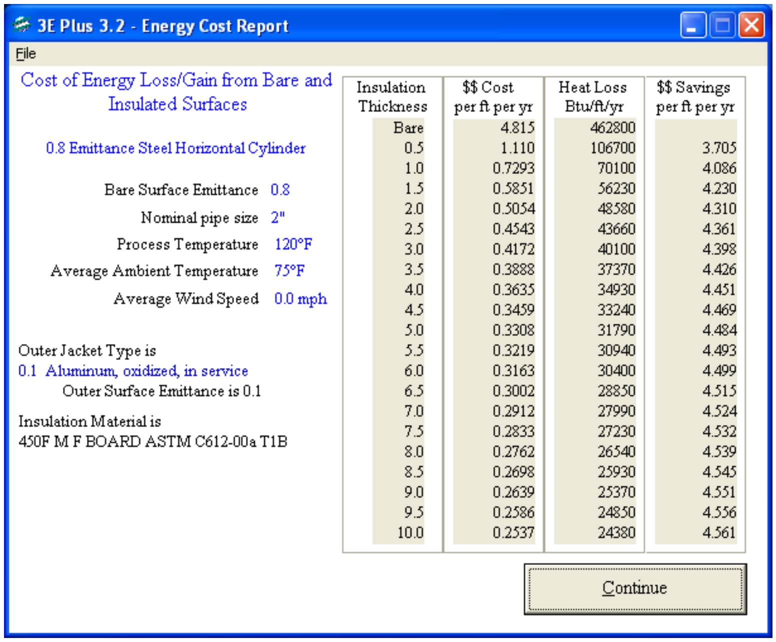
8. Steam and Condensate Leaks (near term)
There were a number of steam and condensate leaks noted that should be repaired, particularly in the old boiler house. A few are:

- There are numerous steam, condensate and feedwater leaks (old boiler house), some severe;
- The pressure relief valve on the desuperheater line has failed and is releasing hot water to the floor;
- The vent valve on the 150-psig header is leaking steam
- Various drip legs were noted to be sending condensate to the ground

Estimation of leak rates is difficult to do with any level of accuracy, however, based on observation, it is expected that repair of the leaks could easily save over $20,000 per year. Most of these should have a return of less than one year and the recommendation is repair as soon as possible.

Note:
Since leak detection was not a focused effort but many were noted, it is recommended that a leak detection and repair assessment be performed.

9. Insulate Steam Valves and Regulators and Fittings
With natural gas at $8.00 per million Btu any pipe 2-inches in diameter or greater with a surface temperature greater than 120°F should be insulated. The screen shot below is a 3EPlus model run that shows the cost savings possible when insulating 2-inch pipe with a surface temperature of 120°F. If a reasonably large quantity of insulation is required, the installed cost of insulation for this pipe is estimated at $6 to $10 per lineal foot. The simple return would be in the range of two to two and one-half years.



3E Plus 3.2 - Energy Cost Report

File

Cost of Energy Loss/Gain from Bare and Insulated Surfaces

0.8 Emittance Steel Horizontal Cylinder

Bare Surface Emittance 0.8

Nominal pipe size 2"

Process Temperature 120°F

Average Ambient Temperature 75°F

Average Wind Speed 0.0 mph

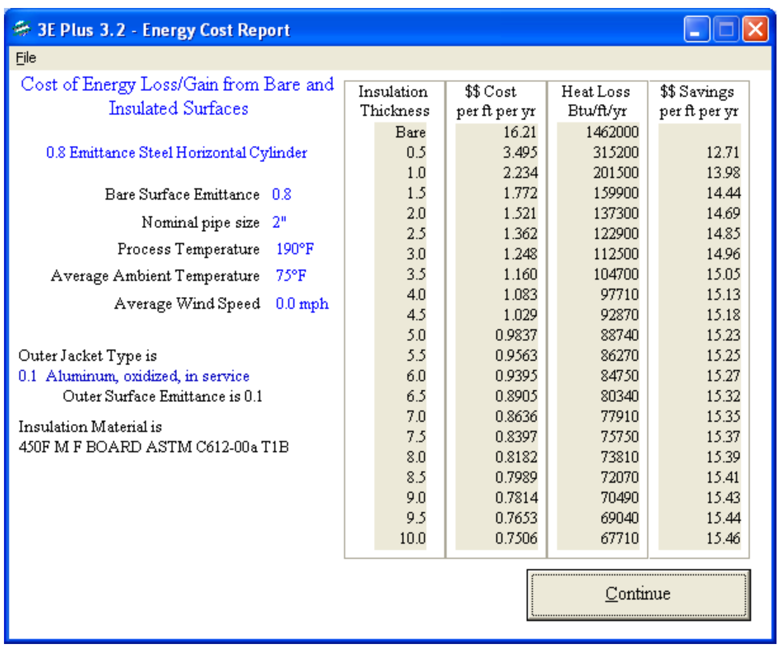
Outer Jacket Type is
0.1 Aluminum, oxidized, in service
Outer Surface Emittance is 0.1

Insulation Material is
450F M F BOARD ASTM C612-00a T1B

Insulation Thickness	$$ Cost per ft per yr	Heat Loss Btu/ft/yr	$$ Savings per ft per yr
Bare	4.815	462800	
0.5	1.110	106700	3.705
1.0	0.7293	70100	4.086
1.5	0.5851	56230	4.230
2.0	0.5054	48580	4.310
2.5	0.4543	43660	4.361
3.0	0.4172	40100	4.398
3.5	0.3888	37370	4.426
4.0	0.3635	34930	4.451
4.5	0.3459	33240	4.469
5.0	0.3308	31790	4.484
5.5	0.3219	30940	4.493
6.0	0.3163	30400	4.499
6.5	0.3002	28850	4.515
7.0	0.2912	27990	4.524
7.5	0.2833	27230	4.532
8.0	0.2762	26540	4.539
8.5	0.2698	25930	4.545
9.0	0.2639	25370	4.551
9.5	0.2586	24850	4.556
10.0	0.2537	24380	4.561

Continue

The screen shot below shows the value of insulating the 2-inch diameter condensate (or hot water) pipe, such as can be found in the old boiler house. At a temperature of 190°F and assuming that there is a reasonable amount of insulation to be installed the insulation cost is approximately $10 per lineal foot. At this price the simple return is approximately 1.5 years.



3E Plus 3.2 - Energy Cost Report

File

Cost of Energy Loss/Gain from Bare and Insulated Surfaces

0.8 Emittance Steel Horizontal Cylinder

Bare Surface Emittance 0.8

Nominal pipe size 2"

Process Temperature 190°F

Average Ambient Temperature 75°F

Average Wind Speed 0.0 mph

Outer Jacket Type is
0.1 Aluminum, oxidized, in service
Outer Surface Emittance is 0.1

Insulation Material is
450F M F BOARD ASTM C612-00a T1B

Insulation Thickness	$$ Cost per ft per yr	Heat Loss Btu/ft/yr	$$ Savings per ft per yr
Bare	16.21	1462000	
0.5	3.495	315200	12.71
1.0	2.234	201500	13.98
1.5	1.772	159900	14.44
2.0	1.521	137300	14.69
2.5	1.362	122900	14.85
3.0	1.248	112500	14.96
3.5	1.160	104700	15.05
4.0	1.083	97710	15.13
4.5	1.029	92870	15.18
5.0	0.9837	88740	15.23
5.5	0.9563	86270	15.25
6.0	0.9395	84750	15.27
6.5	0.8905	80340	15.32
7.0	0.8636	77910	15.35
7.5	0.8397	75750	15.37
8.0	0.8182	73810	15.39
8.5	0.7989	72070	15.41
9.0	0.7814	70490	15.43
9.5	0.7653	69040	15.44
10.0	0.7506	67710	15.46

Continue

The screen shot below shows the value of insulating 2-inch diameter *steam* pipe. With pipe insulation cost on the order of $10 per lineal foot, the simple return is approximately4 months.

3E Plus 3.2 - Energy Cost Report

File

Cost of Energy Loss/Gain from Bare and Insulated Surfaces

0.8 Emittance Steel Horizontal Cylinder

Bare Surface Emittance 0.8

Nominal pipe size 2"

Process Temperature 350°F

Average Ambient Temperature 75°F

Average Wind Speed 0.0 mph

Outer Jacket Type is
0.1 Aluminum, oxidized, in service
Outer Surface Emittance is 0.1

Insulation Material is
450F M F BOARD ASTM C612-00a T1B

Insulation Thickness	$$ Cost per ft per yr	Heat Loss Btu/ft/yr	$$ Savings per ft per yr
Bare	52.64	4749000	
0.5	10.57	953200	42.07
1.0	6.636	598600	46.00
1.5	5.221	471000	47.42
2.0	4.462	402600	48.18
2.5	3.983	359300	48.66
3.0	3.640	328300	49.00
3.5	3.379	304800	49.26
4.0	3.148	284000	49.49
4.5	2.989	269700	49.65
5.0	2.854	257500	49.79
5.5	2.774	250200	49.87
6.0	2.725	245800	49.92
6.5	2.581	232800	50.06
7.0	2.501	225600	50.14
7.5	2.431	219300	50.21
8.0	2.368	213600	50.27
8.5	2.311	208500	50.33
9.0	2.260	203900	50.38
9.5	2.213	199600	50.43
10.0	2.170	195800	50.47

Continue

Valves, regulators, heat exchangers and flash tanks are also areas worthy of insulation. These can be also insulated with "removable" insulation to allow maintenance when necessary. Removable insulation is more expensive than standard pipe insulation (per foot) but is cost effective. The simple return for installing removable insulation on 2, 4, and 6-inch steam valves is expected to be approximately one year. A few suppliers are provided below for convenience but no endorsement of any particular supplier is implied.

- B&B insulation: 920.733.6086
- Advance Thermal Corporation: 630.595.5150
- Coverflex Manufacturing: 713.378.0966

Notes:

1. It is recommended that all condensate return and steam supply piping be insulated. The only exception is on the cooling leg of thermostatic steam traps, since these traps rely on condensate subcooling to function properly. Generally, insulation projects can be considered a "just do it" type projects, with no need to estimate savings since the return will be on the order of one year or less.

Management Support and Comments:
Generally, the initial feedback from the ESA group was favorable. Overall the group was engaged and very interested in identifying ways to reduce mill energy costs.

DOE Contact at Plant/Company: (who DOE would contact for follow-up regarding progress in implementing ESA results…)

Plant Contact: Dave Wagner
Company Contact: Bob Byrne